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ABSTRACT

The Secondary Science Curriculum Review (SSCR) was established in 1981 to consider implications of providing a broader and more balanced approach to science studies for all students aged 11 to 16 years, and to stimulate and support the development work required to enable schools to make appropriate curricular provision. This paper, addressed to those interested in the form and content of science education programs for these students, presents the rationale and framework of a curriculum development program established by the Steering Committee of the Review. Sections 1 to 6 outline the background of the program to be undertaken between April 1983 and August 1986. A new direction for science studies (including time allocation, aims, criteria for development work, and implementation), program organization, and projected outcomes are among the areas considered. Sections 7 to 9 invite a wide range of agencies to consult with the SSCR on the implications of various development proposals. Various issues and questions are directed to specific audiences to assist them in providing input. These audiences include college faculty, professional associations, examination boards, employers, science teachers, subject teacher associations in areas other than science, and others. (JN)

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SCIENCE EDUCATION 11-16:

proposals for action and consultation

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SECONDARY SCIENCE CURRICULUM REVIEW

SCIENCE EDUCATION 11-16 :
proposals for action and consultation

April 1983

This consultative paper incorporates a bold and imaginative set of proposals which will lead to a significant re-orientation of science education programmes for all young people aged 11-16 years. It reflects a widespread view that enhanced scientific and technological literacy set within a broad general education is central to economic growth and social wellbeing, and may help young people better manage the complex demands of life in an advanced technological democracy. The proposals in this paper represent a major challenge to the education system and to all those who support it. It is published in order to involve a wide community of interests in the complex process of enabling education through science and technology to further extend excellence whilst increasing educational opportunity. The paper, in both content and format, invites critical comment and constructive commentary from a wide range of individuals and agencies. It is hoped that through their response readers will be able to inform and influence the developments described herein.

Dr R. W. West Director,
Secondary Science Curriculum Review

Professor J. J. Thompson Chairman,
Steering Committee

April 1983

Note to readers

Sections 1-6 of this paper set out the background and details of a programme of curriculum development to be undertaken between April 1983 and August 1986. Sections 7-9 invite a wide range of individuals and agencies to consult with the Secondary Science Curriculum Review on the implications of these development proposals. To assist readers specific questions are directed to particular audiences in sub-sections 8.1-8.7 as indicated in the Contents.

The Director of the Review will be pleased to discuss the content of the paper or clarify issues with individuals and agencies prior to any formal response should this be necessary.

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SECONDARY SCIENCE CURRICULUM REVIEW

SCIENCE EDUCATION 11-16

1. Introduction

It is now widely accepted that science should have a place in the education of all young people of compulsory school age whether or not they go on to follow a career in science or technology. The Secondary Science Curriculum Review was established in September 1981 to consider the implications of providing suitable science courses for all students aged 11-16 years, and to stimulate and support the development work that is required to enable schools to make appropriate curricular provision. This paper, which is addressed to a wide range of bodies and agencies who have an interest in the form and content of science education programmes for students aged 11-16 years, presents the rationale and framework of a development programme established by the Steering Committee of the Review. It is the Committee's hope that the development work undertaken over the next three years will be informed and shaped by responses to these proposals from other agencies, thus ensuring that the Review's eventual proposals for restructuring the science curriculum have a high level of acceptability amongst teachers in schools and in further and higher education, administrators and employers.

2. Status of the Development Programme

The Steering Committee of the Secondary Science Curriculum Review consists of representatives of the sponsors of the Review - The Association for Science Education, the Department of Education and Science, the Health Education Council, the Northern Ireland Council for Educational Development, and the Schools Council - together with representatives of the Examination Boards and the Standing Conference on University Entrance.

The development programme, which will be completed by August 1986, is supported by a budget of approximately £1 million, and has the further support of the majority of Local Education Authorities in England and Wales as well as the five Education and Library Boards in Northern Ireland.

3. Background to the Programme

The proposal that all young people of compulsory school age should study science has profound implications for schools especially if we accept the desirability of providing a broader and more balanced range of courses. Over the last thirty years considerable progress has been made towards providing science education for all students up to the age of 16 years. Almost all young people now study science in some form up to the end of their third year in secondary school (age 13+) and the numbers taking one or more science subjects in Years 4 and 5 have risen throughout the last decade. It is clear however that current provision suffers from a number of important weaknesses.

It is widely accepted that many current examination syllabuses for the General Certificate of Education (GCE) and the Certificate of Secondary Education (CSE) are overloaded with content and tend to be out of date, too narrow and lacking in much that is directly relevant to adult and working life. Syllabuses, and the way they are taught and examined, tend to create a pressure to learn and recall facts, concepts and principles, but restrict the application of knowledge to well-known and often contrived situations. Students are rarely required to analyse and evaluate their store of knowledge or to apply it in practical situations to solve realistic problems.

A second major weakness of current provision arises from the subject option system that operates in most schools at the end of Year 3. Although, as has already been stated, the overall numbers of young people studying science in Years 4 and 5 have risen over the last decade recent surveys have indicated that about one in ten are not studying any science after the age of 13+, i.e. about 94,000 students in each of Years 4 and 5 in schools in England, Wales and Northern Ireland in 1980. In addition the number of boys and girls taking one or more science subjects varies considerably. Tables 1 and 2 (see pages 3 and 4) illustrate, from different sources, the pattern of subject choice for the sciences in England, Wales and Northern Ireland for the year 1980-81.

Given the very low take-up of general and integrated science courses and the small proportions of boys and girls taking all three sciences, approximately 73% of boys and 81% of girls are failing to study a broad range of subject content in Years 4 and 5. The problem is further exacerbated by the imbalance created between the sciences and other sectors of the curriculum when young people do select all three science subjects. Tables 1 and 2 also show the sharply differential take-up of science subjects by boys and girls and the continuing low proportion of girls studying the physical sciences.

One result of this is that we are producing far fewer young people qualified in science than we either could or should do. Table 3* compares the proportions of students who are successful in English and mathematics - subjects which have always been given due priority - and the much lower proportions in science. This situation directly affects the number of young people able to continue their science studies beyond 16.

Taken together these factors contribute to the quantitative problem of young people qualifying for careers in science, technology and engineering and may also affect the attitudes held by many adults towards science, technology and industry.

Finally it is clear that few existing programmes of study create opportunities for any systematic treatment of areas of science outside biology, chemistry and physics. Subjects such as astronomy, the earth sciences, applied science and technology can gain a foothold only through separate and often specialist O-level and CSE syllabuses, which create further problems of choice and curricular balance whilst attracting only small numbers of candidates.

*data for schools in England only

Table 1 Student subject choices in Years 4 and 5
England, Wales and Northern Ireland (1980 data) (1)

Subject Choices	Percentages	
	Boys (2)	Girls
Biology, chemistry & physics Total three subjects	14 14	9 9
Biology & chemistry Biology & physics Chemistry & physics Total two subjects	3 7 14 24	10 4 3 17
Biology only Chemistry only Physics only Total one subject	7 2 18 27	33 3 3 39
General Science Human Biology Other combinations Total	13 2 12 27	10 11 0 21
No science Total	7 7	14 14

(1) Source: Assessment of Performance Unit Science in Schools Age 15:
Report no. 1 (HMSO, 1982) p.19

(2) Percentages as shown in the above report which total 99% for boys.

Table 2 Student Subject choices in Year 4 Northern Ireland Schools (1)

Subject Choices	Percentages	
	Boys	Girls
3 sciences	13	10
2 sciences	18	10
1 science	49	41
0 science	20	39

(1) Source: Unpublished figures from a sample survey of Northern Ireland secondary and grammar schools during the 1980/81 school year. Presented with the permission of the Department of Education for Northern Ireland.

Table 3 Numbers of students in England gaining GCE "pass" and equivalent CSE grades by subject and as percentages of the age cohort (2)

	Numbers			% of age cohort
	Boys	Girls	Total	
Total age cohort	401,000	382,000	783,000	100.0
Numbers with GCE grades A-C or CSE grade 1 in				
Biology	47,590	68,850	116,440	14.9
Chemistry	54,140	31,150	85,290	10.9
Physics	74,940	26,680	101,620	13.0
Other science	68,320	10,690	79,010	10.1
English	119,930	153,750	273,680	35.0
Mathematics	112,310	87,480	199,790	25.5

(2) Source: Statistics of School Leavers CSE and GCE England 1981 (Department of Education and Science 1981).

4. A New Direction for Science Studies

Recent statements by the Department of Education and Science [DES], the Association for Science Education [ASE], and the Royal Society indicate that a consensus exists in favour of a broader and more balanced programme of science studies for young people aged 11-16 years. The Review endorses that consensus and is convinced that the way forward is best met by defining clearly the parameters of the science component of the secondary school curriculum whilst at the same time encouraging the establishment of flexible working links with other subject areas. The parameters we wish to define are the time to be allocated to science studies, the aims of science education programmes and the educational criteria that should be met in development work.

4.1 Time allocation The Review intends that all development work should be based on the assumption that all students will undertake science studies which occupy at least

- 10% of total curricular time for students aged 11-13, and
- 15% of total curricular time for students aged 13-14; and about
- 20% of total curricular time for students aged 14-16.

This time allocation is compatible with that suggested by the DES and the ASE in recent papers (see Appendix 4).

4.2 Aims In order to satisfy the demand for a broader and more balanced approach to science studies the Review will initiate development work that enables schools to provide, at appropriate stages of a five year programme, adequate opportunities for all students to

- a) explore the nature of the biological and physical environment through observation, experiment and systematic inquiry;

develop the ability to design and carry out experiments, evaluate evidence and solve problems;

study the key concepts and principles of science that are essential to an understanding of science as a way of looking at the world;

study those aspects of science that are essential to an understanding of oneself, and of one's personal well being;

- b) use their knowledge of science to design and develop solutions to technological problems, to test and evaluate those solutions and to cost such exercises;

study the key areas of science and technology that relate to the world of work and leisure so that they are better able to participate in a democratic society;

study key concepts that are essential to an understanding of the part science and technology play in a post-industrial and technological society;

- c) gain some understanding of the historical development and contemporary cultural significance of scientific principles and theories;

appreciate that technologies are expressions of the desire to understand and control the environment and that technologies change in response to changing social needs;

appreciate that past scientific explanations were valid in their time and that early technologies are still valid in some cultural contexts;

- d) discuss, reflect upon and evaluate their own personal understanding of key scientific concepts, theories and generalisations;

explore topics or themes which exemplify the limitations of scientific knowledge as an explanation of the human condition.

4.3 Criteria for development work

Whilst the total development programme will be framed by the above aims, individual projects will be initiated which will seek to develop appropriate materials and teaching strategies to exemplify different aspects of these aims by setting out in detail how appropriate understanding, skills and attitudes can be achieved. In evaluating the outcomes of development work the Review will pay particular attention to the extent to which the programme, and components within it, meets the following criteria.

- a) The Review's programme of work over five years must include an appropriate, coherent and parsimonious selection of content drawn from biology, chemistry and physics suitably augmented by the inclusion of subject matter from other areas of science. In meeting this requirement due attention will be given to extending developments from current good practice in science education at primary, secondary and tertiary levels, and to guarding against content overload.
- b) In selecting a broad and balanced range of content and skills attention will be given to ensuring that the solutions adopted will extend educational opportunity for all students by meeting in full the needs of the most able whilst providing appropriate opportunities for the average and less able students to benefit from a programme of work that is stimulating, challenging and related to everyday life.
- c) In meeting the requirement to extend educational opportunity for all, due attention will have to be given to the need to develop curriculum materials from an initial analysis of the needs and aspirations of the average student; to ensuring that careful attention has been given to problems of progression and cognitive growth; that learning objectives have been carefully matched to teaching strategies and that both are matched to student abilities and expectations; and that any extension studies provided for students with particular interests, abilities or difficulties are consistent with the broad aims of the total programme.
- d) All development work must incorporate proposals for the evaluation and assessment of learning outcomes and for reporting assessments to students, teachers, parents, employers and institutions of further and

higher education. Assessment procedures will be required to reflect fully the intentions of courses and should, where appropriate, include proposals for tests and formal examinations.

Within this brief some projects may explore separate science courses with due emphasis placed on the need for greater co-ordination of work in order to meet the time constraints. Other projects will focus on combined or integrated approaches, and two subject models such as physical science/biological science. It is our intention to encourage and support work on all these models so that their advantages, disadvantages, support and resource implications, and organisational consequences can be fully evaluated and compared.

4.4 Implementation

In presenting the above framework of aims and criteria set within a defined time allocation, it is recognised that considerable flexibility and inventiveness will be required throughout the development process to establish a programme of tested and evaluated units and courses that meet these very stringent conditions. It is also important to note that the final outcomes of the Secondary Science Curriculum Review should be capable of flexible implementation given the very diverse nature of secondary schooling in England, Wales and Northern Ireland. The Review is convinced that the framework of criteria and principles presented will, when fully realised set out the essential requirements of any system of science courses appropriate to the needs of all young people aged 11-16 years. It is firmly of the view that courses meeting these criteria can provide a sound and valid foundation for further science studies at the Advanced Level in the General Certificate of Education, and for courses in Further and Higher Education. The Committee is convinced that developments along the lines proposed will do much to broaden the appeal of science studies in school and hence to increase the numbers of boys and girls who are qualified and willing to pursue studies in science, technology and engineering post-16.

5. Organisation of the Development Programme

The Secondary Science Curriculum Review will operate at three levels with adequate provision for intensive discussion and interaction across the levels.

The basic units for development work will be groups of practising teachers and others, organised and resourced mainly by a Local Education Authority (in England and Wales) or an Education and Library Board (in Northern Ireland). Each group will work to a development brief approved by both the authority and the Review, and will be co-ordinated by a teacher acting as full or part-time convenor/reporter.

The local development groups will be supported and co-ordinated on a regional basis by one of six full-time Regional Project Leaders funded by the Review. These experienced science teachers will maintain direct contact with all working groups and also organise a series of regional meetings throughout the development period. The Association for Science Education, a co-sponsor of the Review, will act as a 'seventh region' by providing

complementary working groups under the co-ordination of the Association's Deputy General Secretary who will be part of the Central Team.

The third tier consists of Regional Project Leaders and the central staff of the Review who are responsible for the overall co-ordination and control of the development programme and the production of all reports, materials and curriculum proposals. This Central Team, in conjunction with the Steering Committee, will also be responsible for liaison with external agencies and for the dissemination of the outcomes of the Review. They will be responsible for ensuring that these outcomes meet the stringent criteria detailed on pages 5 and 6. This structure is presented diagrammatically in Appendix 3.

6. The Projected Outcomes of the Review

It is our intention to publish the following.

- a) A policy report that spells out for schools, examination boards, employers and further and higher education the detailed rationale, criteria and framework for the 11-16 curriculum in science. The report will detail content, process and pedagogic aims, discuss the selection of appropriate teaching and learning strategies, establish appropriate assessment, evaluation and examination criteria, and consider a number of organisational models for the effective implementation of the 11-16 curriculum proposals.
- b) A series of tested and evaluated curriculum packages that illustrate a range of alternative definitions of our proposals at the classroom level. These will include modules, themes and topics that can illustrate the framework established in [a] above. The series may also include carefully documented studies of approaches which fail to meet the stringent criteria established by the Review.
- c) A summary report that provides a working key to the final range of alternatives developed by the Review and indicates the advantages and disadvantages of different routes, pathways and organisational structure.
- d) A comprehensive report of the outcomes of the consultative processes initiated by this paper which will evaluate and document the full range of opinions expressed by different bodies and agencies.
- e) A detailed evaluative study of the Review as an innovation exercise.
- f) Proposals for initial and in-service teacher education programmes.

A further - and highly significant - outcome of the Review will be the involvement of the large number of local education authorities and teachers in the process of curriculum review, and the establishment of a network of review groups that can monitor and continually improve the science curriculum long after the life of the project. Although this may be the most complex and difficult objective to achieve it may well be, in the long term, the most influential.

7. The Purpose of Consultation

The success of this complex programme of curriculum development cannot be assured unless several outside agencies are willing to enter into a dialogue with the Review on the above proposals. In inviting comment on this paper we are conscious that a high level of consultation and dialogue can do much to refine further the criteria and thus improve the quality of the final products of the development programme. We therefore address the following questions to the various audiences who will receive this paper and would greatly welcome responses to them. As our consultative process is an open one we would hope that agencies, whilst responding from their specialist perspectives, will also wish to comment on the broader issues raised by our proposals.

8. A Request for Views and Comments

8.1 Higher Education and the Professional Bodies including the Royal Society

The Review is deeply conscious of the need to explore in detail with the higher education community the ramifications and implications of any proposed change to the science curriculum 11-16. It is a truism to state that no sector of education is an island unaffected by the norms and values of other sectors.

8.1.1 In initiating consultation it seems appropriate to make the following observations:

- a) We fully recognise that higher education has a number of particular interests with respect to the curriculum in schools. One major interest is the further development of science, technology, engineering and professional education in the science based or related vocations. Higher education is, therefore, primarily concerned with the educational standards attained by those boys and girls who achieve most as a result of their secondary education linked to the requirement of maintaining academic and professional excellence.
- b) We also recognise that one of the tasks of the secondary school is to prepare boys and girls to meet the challenge of higher education and participate in the intellectual and general life of our institutions of higher education.
- c) We accept that early specialisation in schools and a very academic and theoretical approach to subject content does equip many youngsters for advanced scientific and technological studies post 18. Traditional O-level teaching in biology, chemistry and physics does enable youngsters to achieve their A-levels and read those same subjects at university or polytechnic. It also prepares many for studies in medicine, veterinary science, applied science, engineering and technology.

8.1.2 Before considering the advantages and disadvantages of an alternative approach to the form and content of school science programmes for the 11-16 year old the Review would wish to note that

- a) it is not convinced that early specialisation is the only route to A-level and degree studies, or that it necessarily represents the best route. It is clearly a route that appeals only to a minority of school-children and possibly only to youngsters with particular personality traits;
- b) society in general and the scientific community in particular pays a high price for early specialisation especially when, as is increasingly the case, the demand for specialist courses inhibits adequate provision elsewhere. The major debit is that the potential baseline for recruitment to science and engineering is strongly limited by current assumptions regarding course content and teaching styles to O-level. Thus the 13+ option pattern filters out many able children who are unwilling at that stage to commit themselves to a strongly science biased curriculum, and, implicitly, to a scientific or technological career. The same applies to able youngsters who at that point of immaturity are not attracted to the world of science and engineering. The option pattern and early specialisation also has the effect of inhibiting many able girls from opting for the physical sciences. All this restricts the total number of young people who are still in sufficient contact with science to consider taking science subjects at A-level;
- c) a further consequence of early specialisation and current examination syllabuses is the production of able youngsters who wish to study biology without any real background in mathematics or the physical sciences, and of physical scientists who know little biology;
- d) schools, in addition to meeting the needs of future scientists and technologists, also have to meet as fully as possible the needs and aspirations of large numbers of youngsters who will not study science to A-level, proceed to higher education or take part in the creation of scientific ideas or technological products;
- e) the enterprise of science, technology, engineering and medicine relies to an increasing extent on the understanding and goodwill of the community at large - a community which is currently ill-prepared to participate rationally in matters of scientific and technological import.

8.1.3 Our proposals for the restructuring of science teaching programmes seek to improve the general quality of provision, and increase the pool of qualified young people by reducing some of the least beneficial consequences of early specialisation. In particular we would argue that

- a) our proposals will lead to a situation in which all young people will have studied and developed a basically common framework of content and skills albeit to different levels of sophistication and understanding;

- b) all students will study to the age of sixteen at least the central concepts of biology, chemistry and physics and hence in an important sense will have studied more science and will have done so in a properly co-ordinated manner. The most able will thus be better prepared to meet the academic and general criteria that are of interest to higher education;
- c) all students will have the opportunity to develop problem solving skills set in realistic contexts, will have undertaken a technological project of some significance, and will have a better balance than hitherto between the study of the pure and applied aspects of science;
- d) all students will have a better range of appropriate study skills and should be able to communicate more effectively;
- e) no aspect of our proposals shall disadvantage students wishing to follow normal science A-level courses. In fact we believe that our proposals will form a better preparation for A-level than the current content-dominated O-level and CSE courses provided by schools.

This move towards a broader and more co-ordinated programme of science studies would require a substantial modification of examinations at sixteen plus and the utilisation of a more flexible range of techniques for examining and reporting on the content, skills and understandings explicit in our proposals.

8.1.4 Whilst we fully appreciate that the ultimate acceptability of our proposals will rest on the quality and validity of the curricular outcomes that are produced to meet the criteria we have presented, we invite higher education and the professional bodies to comment on the above statements and the proposals that underpin them. In inviting comment we would wish respondents to note that our proposals represent a rearrangement of the profit and loss account that frames any approach to the science curriculum. We would particularly welcome views on

- a) the general desirability of a broader and more balanced approach to science studies up to sixteen-plus;
- b) the extent to which a more co-ordinated approach will provide a sounder base for A-level and degree studies and reduce problems of early specialisation;
- c) the extent to which higher education and the professions will accept the consequent restructuring of sixteen-plus examinations and the courses underpinning them that our policy will require;
- d) the extent to which it is felt that the general educational implications of our proposals can in the long term improve the general level of scientific literacy, and hence attitudes in the population at large, to scientific and technological activities.

8.2 Further Education

Due to changes in the nature of provision for 16-19 year olds it is increasingly important to examine carefully the implications of our proposals at a range of levels. From the perspective of students taking GCE A-level courses most of the points made in Section 8.1 are as pertinent to further education as they are to higher education. Where the situation is different is in respect of non A-level courses and the inherent problems of match and progression. The Review feels however that its proposals are broadly compatible with the recent policy statement of the former Technician Education Council and with much of the thinking of the Further Education Curriculum Review and Development Unit. We also hope that by placing a greater emphasis on problem solving skills and the applications of science and technology we will be providing an appropriate context for programmes linked to the New Technical and Vocational Education Initiative and other Manpower Services Commission developments. In considering our proposals as they affect the full ability range encompassed by further education we would welcome comments on

- a) specific issues arising from our proposals that may affect the provision of A-level and BTEC courses. Do our proposals create any major discontinuities or areas of incompatibility?
- b) the articulation between our proposals and the aims, objectives and content of lower level vocational and educational courses in further education;
- c) any perceived difficulties that might arise from the style of science courses we are proposing and the teaching and learning styles of further education, especially with respect to the part-time student;
- d) the implications of our proposals with respect to reporting levels of work and achievement on transfer from school to further education.

8.3 Examination Boards and the Secondary Examinations Council

It is critically important that any attempt to restructure the science curriculum should involve the examination system from the outset. This is particularly important with respect to an initiative that seeks to build upon a widespread consensus in favour of radical changes to present curricular provision. Our proposals rightly place a consideration of the curriculum first but our development plans incorporate systematic treatment of evaluation, feedback, assessment and reporting. Inevitably the detailed realisation and implementation of our proposals will present a major challenge to the examination system and will require a constructive and flexible response. We believe that the examination system is a major repository of expertise that could greatly assist the complex procedure of converting the outcomes of our development work into detailed syllabuses that can be examined. In addition we will need the support of the examination boards at the local and regional levels during a period when it may be important to make interim arrangements to cover schools involved in experimental work.

In consulting the examination system at this early stage we would welcome comment on

- a) the feasibility of our framework and criteria, and indications of any specific areas of difficulty that will require detailed attention at an early stage;
- b) how best to create an appropriate interaction in policy and operational terms between the Review, its development groups and the examination boards;
- c) how best to incorporate emerging national criteria in development work and, where necessary, how to negotiate the development of national criteria that reflect aspects of our aims not currently emphasised in the science curriculum;
- d) ways and means of enabling development work to be undertaken without prejudice to the examination opportunities of young people involved in such work.

8.4 Employers and Trades Unions

In soliciting comments from employers and trades unions we are conscious that young people are recruited at a range of levels and with markedly different perceptions as to the skills and qualities they will bring to their employment. As far as graduate and A-level recruitment is concerned we would refer readers to the arguments presented in Section 8.1 addressed to higher education and the professional bodies. Our case, basically, rests on the assertion that the restructuring of provision for the 11-16 year old will lead to a sounder and more broadly based preparation for A-level and undergraduate studies which will be likely to involve a wider cross-section of boys and girls.

As far as recruitment at 16+ is concerned we would wish to argue that a science curriculum that meets a broadly agreed framework of common content and skills would be beneficial to employers recruiting at this level. We hope employers will welcome an approach to science studies that emphasizes scientific, technological and communication skills and which encourage young people to adopt a critical and inquiring attitude towards problems and to develop a reasonable degree of self-confidence and autonomy. Whilst the total knowledge base in any individual science subject will be more limited in our framework the overall programme of studies would be more extensive, equitable, coherent and co-ordinated than it is at present for almost all pupils. Achievement of this aim will have two important consequences for industry. Firstly, it will do much to remedy the situation highlighted in Tables 1-3 on pages 3 and 4 by ensuring that a far higher proportion of young people are better educated in the area of science and technology. Secondly, in the long term, this broader level of scientific literacy will do much to improve the informed consensus of opinion within which industry has to operate. Finally, we submit that although young people would continue to perform at varying levels of competency and understanding our proposals are inherently better suited to the differing needs of young people than the present structure and organisation of science education.

In responding to our proposals we would welcome the views of employers and trades unions on our general framework and ask specifically

- a) if, for the 16 year old, the balance between content, skills and applications we are recommending appears appropriate to the needs of industry and commerce;
- b) if we are justified in placing such a high premium on problem solving, communication, technological understanding and the development of individual and co-operative attitudes;
- c) whether from an employer's perspective our approach to laying the foundation for A-level studies appears credible;
- d) for specific advice as to how the outcomes of science programmes as outlined might best be reported to prospective employers and personnel managers. What categories of performance should we seek to document?

2.5 Science Teachers, Local Education Authorities, Education & Library Boards and Science Teacher Associations

It is essential that any proposals to change the form and content of secondary science education should command the support of science teachers and their employers. Whilst we feel it is important to build upon and further develop existing good practice, our proposals do have profound implications for teachers and those who support them. In particular our proposals

- a) are based on a rationalisation of the time that should be allocated to science which as we have indicated commands the support of the Association for Science Education, the Royal Society and the Department of Education and Science. Such a time allocation means that many students will, in the future, study more science in school although a minority will study less in Years 4 and 5. Would this time allocation create any major problems assuming that the basic arguments in this paper are widely accepted?
- b) reflect a genuine desire to create an appropriate interaction between science, technology and society whilst at the same time enabling existing specialist staff to contribute fully to new programmes. The Review will, in due course, produce detailed proposals for initial and in-service teacher education programmes and we would welcome views on the content and approach of such programmes. What would you see as priorities?
- c) will involve designing approaches to teaching and learning that meet the broad requirement of teaching less content more effectively and doing so in the context of the real world. This suggests that one of our major concerns will be to augment standard laboratory work with a range of additional teaching and learning strategies including group work, project work, resource-based learning, computer-aided learning, and individualised learning, together with extending opportunities for experiential learning through science and technology based work experience and/or community involvement. Providing we can demonstrate

a better match between learning objectives and teaching strategies and accepting that appropriate in-service support can be provided, what further constraints should we attempt to overcome? Would schools be willing, or able, to react to pressure for more flexible allocations of time and resources?

- d) will be supported by a wide range of tested and carefully evaluated teaching and learning materials, and much of the effort of our development teams will be directed to this end. Given the new balance we are seeking to achieve between content, skills and applications what are your priorities with respect to the materials support you will need?
- e) will establish a new balance between content, skills and applications whilst leaving open the question of how the science curriculum might be organised. One alternative is to rely on separate inputs from teachers of biology, chemistry and physics - an alternative that will make heavy demands on teaching teams in terms of planning and co-ordination. Another alternative is to move towards combined or integrated courses which require teachers to work outside narrow specialisations. We would welcome comments on these alternatives and some indication of the implications of these strategies in manpower and support terms.
- f) link the work we are initiating in science education with the broader aspects of curriculum review being undertaken by the local education authorities. In this context we would welcome advice from authorities as to how our work at the local and regional levels can best support continuing review procedures. What models and exemplars should we attempt to produce during our development phase?
- g) are based on the assumption that structural changes can be negotiated successfully with employers and further and higher education. Assuming that this can be achieved, do you see any other major obstacles to the development of science teaching programmes along the lines outlined in this paper? We are not concerned here, of course, with the fine detail and content of the alternative programmes.

8.6 Subject Teacher Associations in areas other than science

The substantive sections of this paper are concerned with proposals to re-orient school science teaching so that it can better occupy a key position in the secondary curriculum for all students. They represent a significant shift away from a preoccupation with highly structured content and thus incorporate a willingness to renegotiate the boundaries between science and other subject areas. The aims and criteria presented in Section 4 offer substantial opportunities for closer working relationships with other subjects and it might be argued that without such links those aspects of our aims that relate to the technological, social, historical and cultural dimensions of new science programmes cannot be achieved. We would welcome comment from other subject teachers on this aspect of our proposals and in particular would like to receive

- a) comment on the tone, direction and viability of our proposals and especially indications of match that may exist with developments and trends in other subject areas;

- b) suggestions regarding areas of inter-subject co-operation or development that might emerge from these proposals especially with respect to possible involvement by others in our development activities;
- c) indications of specific points we should take into account in order that any changes to the content and style of science education will facilitate work in other subject areas, and notes of any areas where changes might create problems;
- d) indications as to areas or topics where joint discussions might lead to some form of planned and concerted action in support of mutually compatible objectives.

8.7 Departments of Education in Universities and Colleges, and Validating Bodies

The development programme outlined in this paper has implications for Departments of Education in terms of initial teacher training, the in-service education of teachers, and educational research. The Review has as part of its brief a requirement to report on the initial and in-service implications of its proposals and will need to work out in detail specific guidelines for courses and other staff development activities. Progress can best be made on this by inviting open collaboration with the training institutions and validating bodies. Similarly we would hope that our whole programme could serve as a focus for research students and staff interested in the development of science education at the policy and operational levels. We invite comment from Departments and others on

- a) the short term implications of our proposals for the initial teacher training of science postgraduates who have followed highly differentiated science courses in school;
- b) the possible long term implications for initial teacher training once this situation has been remedied;
- c) strategies for dealing with the profound in-service education and re-training implications of our proposals at both the award and non-award bearing levels;
- d) strategies for linking university and college research activities and programmes with key aspects of the Review.

9. The Process of Consultation

This paper is addressed to a wide audience and will be widely circulated. It sets out the background, principles and framework for a quite radical restructuring and reorientation of the science curriculum for the 11-16 year old. It seeks to demonstrate how the Review intends to build upon current good practice in order to improve educational standards and extend educational opportunity in a critically important area of the curriculum. Furthermore it seeks to create the basis for a wide range of cross- and inter-disciplinary work that bridges the cultures of science and technology and those of science and the humanities. In presenting the paper we have

addressed specific questions to specific audiences but we would hope that all readers will feel able to respond critically and constructively to the totality of the paper. The Review would particularly welcome comment from organisations or individuals who feel that our proposals represent too radical or too conservative an attempt to restructure secondary school science education for the 11-16 year old.

Given that consultation takes time and that in a significant sense the final validity of our proposals rests in the quality and rigour of the development work which has to be substantially completed by January 1986, readers will appreciate that our work must proceed concurrently with the consultative process. The Review undertakes to consider and evaluate responses to this paper as part of its continuous review and monitoring of all development work. It is also our intention to publish a detailed summary of the response to this paper as a basis for a small number of consultative seminars that will be held during 1984. These seminars will seek further to improve and consolidate the emerging consensus that underpins our work.

All comments on this paper should be forwarded by the end of November 1983 to the Director of the Secondary Science Curriculum Review at the address given below.

R. W. West
Director
Secondary Science Curriculum Review
Harford House
101-103 Great Portland Street
London W1N 6BH

April 1983

SECONDARY SCIENCE CURRICULUM REVIEW

SCIENCE EDUCATION 11-16

Appendix 1

Members of the Secondary Science Curriculum Review Steering Committee

Professor J.J. Thompson (Chairman)

Mr W.F. Archenhold

Dr M. Birchenough

Professor P.J. Black

Mr I.J. Donaldson

Mrs C. Edwards

Mr V. Green (from May 1983)

Mr J.C. Heaney (from September 1981 to March 1983)

Mr G. C. Hill (from May 1983)

Mr E.O. James

Mr J. Lewis

Dr R.T.B. McClean

Mr J. Nellist

Mr N.J. Sanders

Mr J.B. Whinnerah (from September 1981 to April 1983)

April 1983

SECONDARY SCIENCE CURRICULUM REVIEW

SCIENCE EDUCATION 11-16

Appendix 2

Members of Extended Central Team of Secondary Science Curriculum Review

Director : Dr R.W. West
Deputy Director : Mr M.G. Michell
Project Officer : Miss G.A. Larter
Secretary : Mrs P. Lloyd (from May 1983)

Regional Project Leaders :

Anglia : Mr D.M. Watts
Midlands : Mr J.C. Heaney
North East : Mr J.L. Hornsby
North West : Mrs E.C. Ellington
Northern Ireland : Miss E.R. Jarman
Southern : Miss C. Ditchfield

Association for Science
Education Liaison

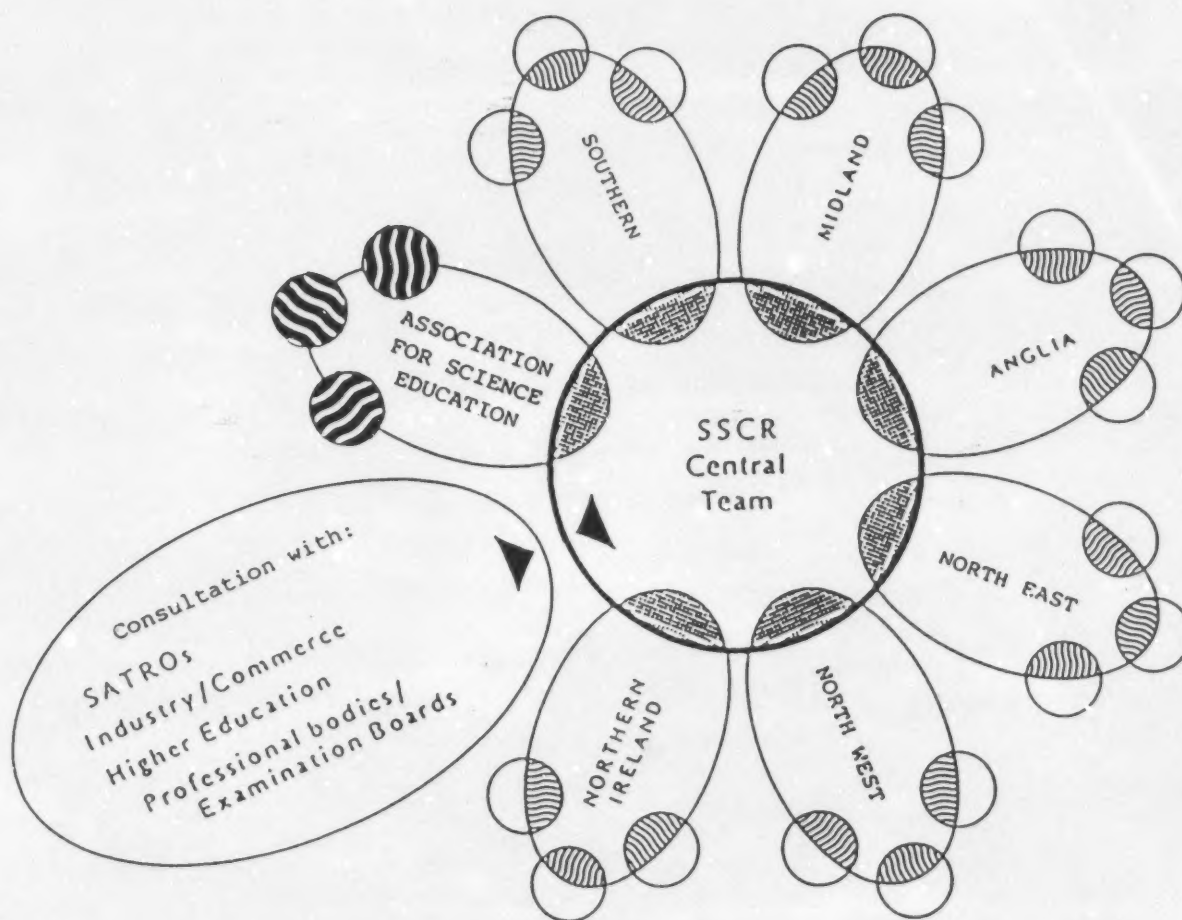
: Mrs C.M. Wilson

Research and Development Officer : Mrs D. Bentley (from September 1983)
(Health and Science Education)

Evaluation Officer : to be appointed

April 1983

Organisational Structure of the Secondary Science Curriculum Review



Key



Short Bibliography

The following papers provide background to the issues discussed in the consultative paper.

1. The Association for Science Education

- 1.1 Alternatives for Science Education: a consultative document (ASE, Hatfield, 1979)
- 1.2 Education through Science: a Policy Statement (ASE, Hatfield, 1981)

2. Assessment of Performance Unit

- 2.1 Science in Schools Age 11 : Report No. 1 (HMSO, 1981)
- 2.2 Science in Schools Age 13 : Report No. 1 (HMSO, 1982)
- 2.3 Science in Schools Age 15 : Report No. 1 (HMSO, 1983)

3. Department of Education and Science

- 3.1 Education in Schools: a consultative document (HMSO, 1977)
- 3.2 The School Curriculum: a consultative document (HMSO, 1981)
- 3.3 Science Education in Schools: a consultative document (DES and Welsh Office, 1982)

4. Her Majesty's Inspectorate

- 4.1 Curriculum 11-16 : Working Papers by HM Inspectorate: a contribution to current debate (HMSO, 1977)
- 4.2 Aspects of Secondary Education in England: a survey by HM Inspectors of Schools (HMSO, 1979)
- 4.3 Girls and Science, HMI Series: Matters for Discussion No. 13 (HMSO, 1980)
- 4.4 Science in Primary Schools (DES, 1983)

5. The Royal Society

- 5.1 Science Education 11-18: a report in summary (The Royal Society, 1982)
- 5.2 Science Education 11-18 in England and Wales: the Report of a Study Group (The Royal Society, 1982) with Annex
- 5.3 Girls and Physics: a report by the Joint Physics Education Committee of the Institute of Physics (The Royal Society/Institute of Physics, 1982)

6. The Schools Council

- 6.1 The Practical Curriculum (Methuen Educational, 1981)

SECONDARY SCIENCE CURRICULUM REVIEW

SCIENCE EDUCATION 11-16

Appendix 5

Timetable of development and consultation

September 1981	Secondary Science Curriculum Review established and Director appointed
June 1982	Development strategy published and local education authorities invited to become involved in development work
April 1983	Central Team appointments completed and development work initiated Consultative procedure initiated by publication of 'Science Education 11-16'
November 1983	Initial responses to 'Science Education 11-16'
January 1984 - July 1984	Development work continues plus a series of consultative conferences and seminars
1985	Final phase of development work and trials
August 1986	Development work completed

April 1983